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# ASSESSMENT ON DIVERGENT REINFORCED POLYMERIC COMPOSITES OF NATURAL FIBER

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***ABSTRACT***

***Throughout the modern epochs, fiber reinforced polymer composites (FRPC) are being ascertained as a precious sustenance as well as appropriate element in the field construction. At the present time, natural fibers are certainly getting abundant consideration from civic engineers throughout globe, as well as application of natural fibers as fortification in polymer fusions for creating affordable construction provisions have also developed widely. Natural fibers do assist numerous beneficial drives, and they are too highly demanded in current period aimed at the numerous applications by way of reinforcement, especially embodied with a work to strengthen polymer matrix. Certainly, the available natural fibers propose numeral recompenses above outmoded artificial fibers for the reason that, they have a superior resistance to corrosion, outstanding thermo-mechanical assets as well as extraordinary asset to heaviness proportion. Consequently, natural fibers provide countless gains when equated with artificial fibers that project them sufficiently capable, by means of reinforcement in fused constituents. This analysis would clearly deliver an appraisal on diverse possessions in natural FRP amalgams, aimed at numerous applications, specifically in the arena of substructure/civil infrastructure.***

***KEYWORDS: Natural Fiber, Reinforced Polymer Composites, Reinforcement & FRP***

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Original Article

## 1. INTRODUCTION

Fiber Reinforced Polymer (FRP) fused rudiments, undeniably have advanced into the aspect of affordability as well as architecturally feasible structure materials designed for weight bearing rudiments in substructure plus bridges, since few decades. Utilization of FRP amalgams amidst civic substructures could definitely develop novelty or innovations, upsurge efficiency, augment the performance, in addition, they can offer lengthier service lives which would mean abridged expense in the life cycle [3]. A progress in the utilization of Fiber reinforced polyamide compounds amidst the civic substructures has been evidently noticed. These composites are being used in numerous applications fluctuating between reinforcing/strengthening dowels and sinews, swathe in seismic retrofits aimed at the aspect of support and outwardly fused reinforcement in-order to solidify the walls, grins and hunks, entire compound bridge decks, likewise crossbreed (FRP mixtures aligning together with conservative materials) composite mechanical classifications [8]. Utilization of FRP amalgams in solidifying solutions has grown into a proficient substitute to some of the prevailing outmoded approaches, because of certain benefits like their features with regard to the relation to forte, weightlessness and tendency of resistance towards corrosion as well as the easiness of application.

**Table 1: Characteristic Elements of Fibers [7]**

| Properties | Glass | Jute | Coir | Sisal | Cotton |
|---|---|---|---|---|---|
| Density (g/cm3) | 2.567 | 1.47 | 1.25 | 1.34 | 1.51 |
| Tensile Strength (N/mm2) | 2450 | 400–800 | 220 | 600–700 | 400 |
| Stiffness (KN/mm2) | 72 | 10-30 | 7 | 38 | 12 |
| Elongation at break (%) | 3 | 1.8 | 15–25 | 2-3 | 3–10 |
| Moisture Absorption | - | 12 | 10 | 11 | 8–25 |

Abridging own heaviness (table 1), towering asset to precise weightiness proportion, electromagnetic transparency, amplified aversion towards destructive or corrosive elements besides additional mechanical and technical features acclaim these constituents appropriate in structural and mechanical submissions [3]. However, benefits of natural strands above old-fashioned/outmoded strengthening materials like glass fibers or glass filaments for reinforcement, carbon fibers as well as other fibers; are precise asset properties, effortless accessibility, weightless, effortlessness in the aspect of separation, improved energy retrieval, long durability, high resistance towards corrosion, squat compactness, affordable, improved thermal properties, abridged tool wear (in regular operation) as well as slighter abrasion towards the performance of processing apparatus [1].

Fibers made with ethers or esters of cellulose or in other word Cellulosic fibers which is biodegradable and almost no pesticides or fertilizers used (sisal), coir as well as bamboo in their original form in addition to numerous excess cellulosic yields like diatomaceous earth/shell flour, pulverized wood and the lingo cellulosic fibrous material called pulp are being satisfactorily utilized as reinforcing mediators of varied thermosetting besides thermoplastic fusions [4]. Composites are materials, which encompass durable weight carrying substances (identified by means of reinforcement) entrenched in feebler material (recognized in place of matrix). Reinforcement offers toughness and firmness/rigidity, serving to maintain structural freight. The matrix or folder (biotic or else inorganic) preserves the condition as well as location of the reinforcement. [2].

Amalgams of strengthened filaments (FRC) are being utilized in numerous applications since a number of years together with the rapidly flourishing commercial market. It is observable that the adding of filaments to polyamides has copious benefits, particularly the perfunctory possessions of the amalgams Artificial strands like carbon or glass that are strengthened in polyamides to be utilized in supercharged applications like automated industries as well as aircraft productions. [11–13]. The enactment of these complexes has been enhanced uninterruptedly through laborious investigations, frequently by mingling of either two or more reinforcements/polyamides or fillers.[14–17] Nevertheless, these revved-up fusions are challenging in the recycling process as the splitting-up of the constituents are relatively challenging.[18–20] As a result, these compounds are repeatedly squandered in substandard ways like landfills or enflaming that bases a massive conservational impact. Perhaps it is imperious to mention that considerable amount of these polyamides are being produced from petroleum centered exhaustible properties.

Environmental glitches in the contemporary era have compelling us all to look for the requirement of innovative substitutions that can interchange the outmoded FRCs which have less harmful materials towards the environment. [21–24]This has fashioned a transformed attention in natural resources that are utilized as strengthening materials or plasters in the amalgams and are consequently denoted as “natural fiber reinforced composites” [25] or in other words biodegradable complexes. Therefore, these amalgams too are named as “bio-composites.” [26]A number of scholars have come up with concepts of strengthening diverse natural filaments in polyamides to harvest environmental friendly fusions for numerous applications that do not necessitate exceptional mechanical assets like subordinate/tertiary building edifices, car door

boards or panels, wrapping, etc.[23] Utilization of natural filaments as strengthening elements in mixtures has been on the rise and it has substituted a number of strengthened filaments of artificial amalgams in a number of applications like automated industries, maritime productions, aerospace materials, engineering utilization of construction fields, etc. [21–24,27] Primarily, this is because of the wide-ranging research that are being carried out, its exceptional character of ecofriendly or decomposable, economical affordability, plus stimulating physical and mechanical properties (tenuity, better power, processing elasticity, elevated specific arduousness, etc.). [24, 26]

In sequence, the furthermost endeavor has been concentrated on substituting the artificial filaments by natural ones in petroleum-based matrices in-order to produce fusions. The fabrication and classification of these amalgams are examined and the assets also are enriched significantly. [28–34]These compounds have hoarded support because of its responsive element towards environment, substantial decrease of unnaturally replenished properties utilized in fusions, and the substitution of mineral-inorganic constituents with the biological elements of fusions. The utilization of ordinary filaments in the production of fusions fashioned a fresh alternate for the agriculturalists. The prospects of utilizing reprocessed plastics like polyolefin got ahead as it has abridged the ingestion of non-recyclable polyamides.[35–39] Additionally, the decomposable polymers have been resulting from naturally replenished properties, i.e., polylactic acid thermoplastic polyamide of cornflower, soybean grounded thermoset matrix and thus, the amalgams have been prepared entirely from inexhaustible or sustainable assets, mentioned as “green fusions.” [40–47]

Fusions of natural filaments have been utilized in the seats of airplane since 1896. [48]The usages of ordinary strands have disparagingly weakened and have come to a closer cessation because of the increase in the utilization of normal plastics as well as their economical affordability. India and other few countries have sustained these products and the utilization of ordinary filaments as the strengthening material for amalgams in applications like plumbing or pipes, boards or panels, etc., [49] for few decades. The Indian administration has also reinvigorated the amalgams of strengthened natural filament for the constructions like Madras House.[50] Serious deliberations about the eco-friendly constituents and conservation of non-recurring properties recuperated the attention in ordinary fiber compounds.[21] The realization has already taken place as the US market has witnessed the growth of 2.7 billion pounds in 2006 and the same growth has been realized as 3.3 billion pounds in 2013 with the annual increment of 3.3%. Thus, from 1994 to 2004, the progressive level of 13% (0.275 billion kilograms) has been witnessed and the firm requests toward the utilization of natural filaments on its dramatic rise. [52]The worldwide median value of annual market progress for bio-based matrix from the year 2003 to 2007 has been 38%; European countries have also witnessed the risen growth in the market as 48% per annum. The projected growth of the market of bio-based matrix by 3.45 million metric ton by 2020 is definitely high when it is compared to the estimated growth as 0.36 million metric ton in 2007.[53] And there is no doubt that the market for the properties of reinforcement is a commercial demand and invites multibillionaires to invest on natural filaments fusions which is certainly playing a reasonable role in it.[54]

## 2. LITERATURE REVIEW

Okra, which is considered as one of the abundant sources of natural fiber projects and considerable suitability in making of wooden materials for domestic drives with less heaviness when it is produces as armored polymer composite [6]. Tensile modulus of treated okra fastened chemical fiber reinforced polymer fusions exposed linear upsurge in its worth with escalation in proportion capacity segment of fiber.

An analysis [1] upon the amalgams and mechanical possessions of fresh sequence of biotic mixtures encompassing Hibiscus sabdariffa, which is used for the production of bast fiber and as an infusion in urea-methanal and also known as urea-formaldehyde (UF) adhesive, has been accomplished by means of a reinforcing substance. The result exposed the mechanical properties for instance tensile strength, in other words, the capacity of a material or structure to withstand loads, compressive strength that is to say the capacity of a material or structure to withstand loads tending to reduce size as opposed to tensile strength as well as wear resistance, which usually protects the loss of surface by means of some mechanical action of the of UF adhesive improved to significant amount once armored by means of fiber.

Elements and properties of peanut carapace reinforced polymer amalgams (GSPC) were equipped [5] by means of altered load fraction of elements in polymer matrix. Observation was primed that the accumulation of elements enhanced the mechanical equity to certain weightiness, and in addition, declined with constituents of augmented element in the sample. The model projecting the average of 40 %weightiness of peanut carapace element reinforcement has highest coefficiency of fracture in addition to impact strength or forte. The impact assessment's outcome displayed a stable upsurge of 50%impact strength, which is a measure of the amount of energy that a material can absorb before fracturing under high rate of deformation and weightiness of designing composite materials with improved properties and to improve the overall production cost (filler addition).

Ordinary fibrous substances utilized by means of strengthening in polyamide compound were pine spikes gathered from native means [9]. It had been perceived that polyamide fusion acquired by element reinforcement demonstrate improved perfunctory possessions when equated with tiny and also with the lengthier fiber reinforcement. Likewise, the elements of reinforced mixtures display developed obstruction towards enlargement, absorption of wetness and chemical resistance performance because of hydrophilic conduct of lingocellulosic fiber. Exceptional outcomes had been achieved while the pine spikes remained utilized in element structure.

Starch or amylum (a polymeric carbohydrates consisting of a large number of glucose unit joined by glycosidic bonds) [7] is a natural polyamide that owns properties that are countless and exceptional. By way of merging the distinct benefit of starch in addition to artificial polyamides, starch centered recyclable polyamides perceived to stand proficient because of varied accessibility of manufacturing techniques; both ensued in their particular distinguishing produces. Progress in the arena of biopolyamide constituents is definitely encouraging due to its ecofriendly actions.

## 3. NATURAL FIBERS AND CELLULOSE-BASED FIBERS

Man-made and natural fibers are the general categories of filaments. The projected figure: 1 demonstrates the schematic representation of cataloging the filaments. Since a few decades, many of the applications substituted the artificial ones and also have sincerely acknowledged the benefit of natural filaments like affordability, tenuity and reduced tool wear. Extensive usage of natural strands as the strengthening element because of renewability as well as sustainability has fetched a number of filaments into the turf of amalgams. Keeping the origins in mind the ordinary filaments could be classified into three categories they are flora, mineral and fauna fibers. Filaments produced from faunae like hair, silk as well as filaments of mineral are not being generally utilized as strengthening materials. Nevertheless, numerous fibers produced from flora are being broadly utilized in bio-composites arena for submissions in the specific zones of automated industry, maritime productions as well as construction. Reinforced roughage filaments fall amidst ordinary and artificial strands that are being utilized as the strengthening element of fibers in current epochs. This paper mainly discusses about

the natural as well as redeveloped cellulose of filaments that are the significant shares of the strengthening or reinforcing elements of bio-composites.

The mounting apprehension about ecological concerns and on the additional hand, the necessity for extra versatile polyamide based constituents leads to an upsurge in the overall attention in ecological amalgams. This necessity is important scientific investigation to gaze for novel replacements, capable of substituting outdated polyamide mixtures with replacements that have lesser conservational impact which are frequently stated as "eco-composites" or "green composites." These fusions can be considered ecologically receptive when the polyamide matrix is recyclable (e.g., if filled with natural-organic fillers), but also if it originates from renewable bases. The production and characterization of polyamide amalgams based on decomposable polyamides (e.g., polyolefins), filled with natural-organic fillers (e.g., filaments and constituent parts are taken from florae) is an enormously fascinating arena of scientific investigation and industrial progress. Meanwhile, researches have also been attentive on filaments. As an alternative of high-tech fibers like glass, carbon and aramid that are already extensively utilized in oceanic and offshore productions more supportable ones have been taken into concern, such as flax, hemp, and cotton. Even if their level of performance is usually lower when equaled to old-fashioned amalgams, particularly as far as mechanical resistance is concerned, it is remarkable that numerous applications could receive this dreadful condition in necessities in the name of advanced eco-sustainability

### 3.1 Animal Fibers

Filaments of silk from silkworms as well as spiders generally have been detached in diverse means. Cocoons or the armored natural material from mulberry silkworm have been heated moderately in a trivial detergent solution that liquefies the sericin resin adhesives or bonds the strands as well as disentangles the filaments of silk. Then, the filaments could be whirled on top of wheels. Roughage of silk is eroded to eliminate residual sericin in addition to additional impurities. The remotion of silk from spider is of an exhaustive effort, space as well as would take unpredicted period of time. The spider is deadened at a cool troposphere that is then steadied by way of upturning in-order to depict spinnerets. A smaller brush in addition to microscope is utilized for provoking and separating the fibers respectively. And it is mandatory for every filament that is inefficient in the field of economy for the manufactures of industrialized scale. Filaments of wool are normally produced by physically cropping and assembling oily wool filaments that have several scums. Consequently, skirting as well as classing is prepared manually. The oily wool is battered to remove the fresh wool. A number of filaments are taken out in diverse means and then disemboweled to eliminate the foams beforehand the filaments are utilized.

### 3.2 Plant Fibers

The filaments must be detached and removed from soft wooded tissue in the roughage yields afterward the reaping of the plant. The fauna filaments that are utilized in profitable applications, generally roughages of bast have been detached from the filament yields by the saturating procedure. And this retting or saturating method is a progressive method that becomes estranged the filaments' packages from dominant stalk that relaxes the roughages from soft timbered or wooded tissue or kleenex of the filament's crops. The elimination of roughage has an influence upon the filament yield, its superiority, biochemical alignment, structure as well as filaments' properties. There is a number of retting or saturating procedures as displayed in the figure and four chief unraveling procedures are biological, mechanical, physical as well as chemical. Biological movement of microbes like microorganisms besides mildews in the ecology acts as chief component in the dilapidation of the pectic polysaccharides from non-filament soft tissue in addition to the separated packages of strands.

Occasionally, the saturating procedure could be stimulating with regard to the cautiousness intricate as the saturating or under-retting results in adulterated filaments.

## 4. CONCLUSIONS

Natural polyamide mixtures are certainly ecofriendly, and the investigators continuously discover multiple natural fibers that enhance the perfunctory asset of polyamide mixtures. Natural fibers ensued in complex elements, which is weightless. Similarly, because of the squat compactness of normal fibers utilized in the amalgams could be viewed as beneficial and weightless engineering material. It is rather obvious from exceeding considerations that usages of newfangled amalgams are copiously accessible on the prospect of natural fibers; correspondingly, this certainly has fetched renewed developments in amalgamated materials.

Utilization of the ordinary roughages is on its rise in the area of composites because of their characteristics of ecofriendly and affordability. Present commercial zone for natural filaments has been seen a remarkable growth since a few decades. The specialists also predict about a continuous and healthy growth in the mere future of the same field. The exclusively unique possessions of the filaments are much visible as the low density as well as better strength is also observed. It is also the accepted fact that the compounds of natural roughages are being generally utilized commercially in the applications of motorized arena, aircraft, maritime as well as construction engineering. Numerous fusions are being manufactured from a number of fauna and flora despite the fact that these filaments are generally being utilized in the area of industrial gauge. The strengthening elements of natural roughages are expressively advanced since a few decades by on-going efforts and investigations together with the elevated performance of the strengthening material of natural filaments. At present the considerable exploration is being done world-wide on natural filaments in addition to their compounds to advance the assets. The strands as well as fusions are categorized for several mechanical properties with regard to the applications of a number of apparatuses. Additional investigations on roughages as well as their strengthening materials' potentiality are to be completed. Immersion of the thermoisture of the filament as well as fiber-matrix is yet to be given sufficient attention in-order to develop the properties. Presently, the strengthening materials of natural filaments are generally utilized in interior applications in addition to its projected potentiality in alfresco applications could be obviously developed if the matter and problems mentioned above are connected to natural filaments taken care.

***REFERENCES***


1. *A. A. S. Singha and B Vijay Kumar Thakur (2008), Mechanical Properties of natural fiber reinforced polymer composites, Journal of Indian academy of science, vol. 31, 791–799.*
2. *A D. Chandramohan and B K. Marimuthu (2011), tensile and hardness test on natural fiber reinforced polymer composite material, international journal of advanced engineering science and technologies, vol. 6, issue 1, pp. 97–104.*
3. *A Gangarao Hota and B Ruifeng Linag (2011), Advanced fiber reinforced polymer composites for sustainable civil infrastructures, International symposium on Innovation & Sustainability of structures in Civil Engineering.*
4. *A Girisha C., B Sanjeevamurthy and C Gunti Rangasrinivas (2012), Tensile Properties of natural fiber-reinforced epoxy hybrid composites, international journal of modern engineering research, vol 2, issue 2, pp-471–474.*
5. *Sathya, S., Lakshmi, S., & Nakkeeran, S. (2016). Combined effect of biopriming and polymer coating against chilli damping off. International Journal of Agricultural Science and Research, 6(3), 45–54.*

6. *A G. U. Raju, B S. Kumarappa and C V. N. Gaitonde (2012), mechanical and physical characterization of agricultural waste reinforced polymer composites, journal of material environmental science, volume 3, pp 907–916.*
7. *A N. Srinivasababu, B K Murli Mohan Rao and C J. Suresh Kumar (2001), tensile properties characterization of okra woven fiber reinforced polyester composites, International journal of engineering, volume 3, issue 4.*
8. *A N. Abilash and B M. Sivapragash (2013), Environmental benefits of eco-friendly natural fiber reinforced polymeric composite materials, International journal of applications or innovation in engineering & management, volume 2, issue 1, page 53–59.*
9. *A V. M. Karbhari, B J. W. Chin, C D. Hunston, D B. Benmokrane, E T. Juska, R. Morgan, J. F J. Lesko, G U. Sorathia and H D. Reynaud (2003), Durability gap analysis for fiber-reinforced polymer composites in civil infrastructure, Journal of composites for construction, 7(3), 238–247.*
10. *A Vijay Kumar Thakur and B Amar Singh Singha (2010), Physio-Chemical and mechanical characterization of natural fiber reinforced polymer composites, Iranian Polymer journal, volume 19, pp 3–16*
11. *A Shrikant M. Harle (2014), The Performance of Natural Fiber Reinforced Polymer Composites: Review International Journal of Civil Engineering Research, ISSN 2278–3652 Volume 5, Number 3.*
12. *Chawla K. K. "Carbon fiber composites", In: Composite Materials, 2nd Edition; Springer, NewYork, 1998, pp. 252–277.*
13. *Strands G. F. Glass fiber reinforced composite article exhibiting longitudinal tensile and compressive moduli. US Patent 3691000, 1972.*
14. *Brody H;Ward I. M. "Modulus of short carbon and glass fiber reinforced composites", PolymerScience & Engineering 1971, 11(2), 139–151.*
15. *Summerscales, J. "Short D. Carbon fibre and glass fibre hybrid reinforced plastics", Composites 1978, 9(3), 157 166.*
16. *Harris, B.; Bunsell, A. R. "Impact properties of glass fibre/carbon fibre hybrid composites", Composites 1975, 6(5), 197–201.*
17. *Bunsell, A. R.; Harris, B. "Hybrid carbon and glass fibre composites", Composites 1974, 5(4), 157–164.*
18. *Manders, P. W.; Bader, M. G. "The strength of hybrid glass/carbon fibre composites", Journal of Material Science 1981, 16(8), 2233–2245.*
19. *Henshaw, J. M.; Han, W.; Owens, A. D. "An overview of recycling issues for composite materials", Journal of Thermoplastic Composite Materials 1996, 9(1), 4–20.*
20. *Pickering, S. J. "Recycling technologies for thermoset composite materials–current status", Composites Part A: Applied Science and Manufacturing 2006, 37(8), 1206–1215.*
21. *Conroy, A.; Halliwell, S.; Reynolds, T. "Composite recycling in the construction industry", Composites Part A: Applied Science and Manufacturing 2006, 37(8), 1216–1222.*
22. *Bledzki, A. K.; Gassan, J. "Composites reinforced with cellulose based fibres", Progress in Polymer Science 1999, 24(2), 221–274.*
23. *Faruk, O.; Bledzki, A. K.; Fink, H. P.; Sain, M. "Biocomposites reinforced with natural fibers: 2000–2010", Progress in Polymer Science 2012, 37(11), 1552–1596.*
24. *La Mantia, F. P.; Morreale, M. "Green composites: A brief review", Composites Part A 2011, 42(6), 579–588.*
25. *John, M. J.; Thomas, S. "Biofibres and biocomposites", Carbohydrate Polymers 2008, 71(3), 343–364.*

26. *Bogoeva-Gaceva, G.; Avella, M.; Malinconico, M.; Buzarovska, A.; Grozdanov, A.; Gentile, G. E. "Natural fiber eco-composites", Polymer Composites 2007, 28(1), 98–107.*

27. *Mohanty A. K.; Misra, M.; Hinrichsen, G. "Biofibres, biodegradable polymers and biocomposites: An overview", Macromolecular Materials and Engineering 2000, 276–277(1), 1–24.*

28. *Koronis G.; Silva, A.; Fontul, M. "Green composites: A review of adequate materials for automotive applications", Composites: Part B 2013, 44(1), 120–127.*

29. *Ku, H.; Wang, H.; Pattarachaiyakoop, N.; Trada, M. "A review on tensile properties of natural fiber reinforced polymer composites", Composites: Part B 2011, 42(4), 856–873.*

30. *George J.; Sreekala, M. S.; Thomas, S. "A review on interface modification and characterization of natural fiber reinforced plastic composites", Polymer Engineering & Science 2001, 41(9), 1471–1485.*

31. *Sgriccia, N.; Hawley, M.; Misra, C. "Characterization of natural fiber surfaces and natural fiber composites", Composites: Part A 2008, 39(10), 1632–1637.*

32. *Cheung, H. Y.; Ho, M. P. H.; Lau, K. T.; Cardona, F.; Hui, D. "Natural fibre-reinforced composites for bioengineering and environmental engineering applications", Composites Part B: Engineering 2009, 40(7), 655–663.*

33. *Kabir, M. M.;Wang, H.; Lau, K.; Cardona, T. "Chemical treatments on plant-based natural fibre reinforced polymer composites: An overview", Composites Part B: Engineering 2012, 43(7), 2883–2892.*

34. *Xie, Y.; Hill, C. A. S.; Xiao, Z.; Militz, H.; Mai, C. "Silane coupling agents used for natural fiber/polymer composites: A review", Composites Part A: Applied Science and Manufacturing 2010, 41(7), 806–819.*

35. *Dittenber, D. B.; Gangarao, H. V. S. "Critical review of recent publications on use of natural composites in infrastructure", Composites Part A: Applied Science and Manufacturing 2012, 43(8), 1419–1429.*

36. *Malkapuram, R.; Kumar, V.; Negi, Y. S. "Recent developments in natural fiber reinforced polypropylene composites", Journal of Reinforced Plastics and Composites 2009, 28(10), 1169–1189.*

37. *Shubhra, Q. T.; Alam, A. K. M. M.; Quaiyyum, M. A. "Mechanical properties of polypropylene composites: A review", Journal of Thermoplastic Composite Material 2013, 26(3), 362–391.*

38. *Yuan, Q.;Wu, D.; Gotama, J.; Bateman, S. "Wood fiber reinforced polyethylene and polypropylene composites with high modulus and impact strength", Journal of Thermoplastic Composite Material 2008, 21(3), 195–208.*

39. *Torres, F. G.; Cubillas, M. L. "Study of the interfacial properties of natural fibre reinforced polyethylene", Polymer Testing 2005, 24(6), 694–698.*

40. *Malarvizhi, G. (2015). Development of herbal finished baby diapers with bamboo fiber. International Journal of Humanities, Arts, Medicine and Sciences, 3(2), 41–46.*

41. *Sobczak, L.; Brugemann, O.; Putz, R. F. "Polyolefin composites with natural fibers and wood modification of the fiber/filler-matrix interaction", Journal of Applied Polymer Science 2013, 27(1), 1–17.*

42. *Plackett, D.; Andersen, T. L.; Pedersen, W. B.; Nielsen, L. "Biodegradable composites based on L-polylactide and jute fibres", Composites Science and Technology 2003, 63(9), 1287–1296.*

43. *Siracusa, V.; Rocculi, P.; Romani, S.; Rosa, M. D. "Biodegradable polymers for food packaging: A review", Trends in Food Science & Technology 2008, 19(12), 634–643.*

44. *Bax, B.;Mussig, J. "Impact and tensile properties of PLA/cordenka and PLA/flax composites", Composites Science and Technology 2008, 68(7–8), 1601–1607.*

45. *Meier, M. A. R.; Metzger, J. O.; Schubert, U. S. "Plant oil renewable resources as green alternatives in polymer science", Chemical Society Reviews 2007, 36(11), 1788–1802.*

46. *Galia, M.; de Espinosa, L. M.; Ronda, J. C.; Lligadas, G.; Cadiz, V. "Vegetable oil-based thermosetting polymers", European Journal of Lipid Science and Technology 2010, 112(1),87–96.*

47. *De Espinosa, L. M.; Meier, M. A. R. "Plant oils: The perfect renewable resource for polymer science", European Polymer Journal 2011, 47(5), 837–852.*

48. *Sharma, V.; Kundu, P. P. "Addition polymers from natural oils: A review", Progress in Polymer Science 2006, 31(11), 983–1008.*

49. *Guner, F. S.; Yagci, Y.; Erciyes, A. T. Polymers from triglyceride oils. Progress in Polymer Science 2006, 31(7), 633–670.*

50. *Bledzki, A. K.; Izbicka, J.; Gassan, J. Kunststoffe-Umwelt-Recycling; Stettin: Poland; 1995, pp 27–29.*

51. *Pal, P. K. "Jute reinforced plastics: A low cost composite material", Plastics and Rubber Processing and Applications 1984, 4(3), 215–219.*

52. *Winfield, A. G. "Jute reinforced polyester projects for UNIDO/government of India", Plastics and Rubber International 1979, 4(1), 23 28.*

53. *Report NFCM. Natural Fiber Composite Market Report. Little Falls, Kline, & Company: NJ, 2004.*

54. *Shen, L.; Haufe, J.; Patel, M. K. Product overview and market projection of emerging bio-based plastics, PRO-BIP; Final Report, Report No: NWS-E-2009-32. Utrecht University: Utrecht, the Netherlands, 2009, p 243.*

55. *Mirous, A. "Fiber-reinforced plastics use, 2002", In: Plastics News; Plastics News Global Group: Akron, OH, 2002. Available at: http://www.plasticsnews.com/article/ 20020826/FYI/308269999/fiberreinforced-plastics-use-2002*

56. *Venkateshwaran, N.; Elayaperumal, A.; Sathiya, G. K. "Prediction of tensile properties of hybrid-natural fiber composites", Composites: Part B 2012, 43(2), 793–796.*

57. *Behzad, T.; Sain, M. "Measurement and prediction of thermal conductivity for hemp fiber reinforced composites", Polymer Engineering and Science, 47(7), 977–983.*

58. *Woodings, C. Regenerated Cellulose Fibres; Wood head Publishing: UK, 2001.*


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